Abstract

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Thesis title:	**Development and optical characterization of Se based chalcogenide glasses for sensing application**
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Detection and control of humidity is very important in our everyday life. Humidity sensors are used in many areas, such as meteorology, environmental protection, medicine, food industry, agriculture, etc. Various transduction techniques, such as capacitive, resistive, acoustic, optical and mechanical, have been adopted for the design of humidity sensors. For many applications, not only for humidity, but also for temperature it is an important factor. Therefore, there exists a strong demand for simply-fabricated integrated humidity and temperature sensors in many fields. Miniaturization technology has facilitated the development of micro humidity sensors, which generally adopt vapor-absorbent films as their sensing materials. The electric/mechanical properties of these films change as the relative humidity changes, and these changes allow the precise value of the relative humidity to be determined. However, it still remains challenging to develop a sensor which provides a complete set of favorable characteristics, e.g. good linearity, high sensitivity, low hysteresis and rapid response time.

Many research works have been done for development of humidity sensor with the help of oxide and non-oxide materials. But humidity sensor using chalcogenide as sensing membrane is not yet studied by the researchers. These glasses have optically high non-linear properties, have low-phonon energy and are also transparent from the visible up to infrared region. The transparency of chalcogenide glasses is 12 to 15 μm. Due to the property of high transparency in infrared regions

these glasses can be used in sensor application. These glassy alloys are sensitive to the absorption of electromagnetic radiation and have various photo induced effects. These glasses have appreciable mechanical properties like hardness, low internal stress, adhesion in addition with water resistance. Up-to-date level of functional characteristics of chalcogenide fibers is sufficient for their use in various mid and far-IR active and passive applications. Hence in this thesis we have put an effort to develop Ge-Se-Te-Sb/As chalcogenide glasses as sensing membrane for humidity sensors for better sensitivity and good response.

Se based glasses are mostly studied due to their wide applications in microwave filter, voltage controlled oscillator, xerography, switching and memory applications, sensors etc. Though Se based glasses are thermally unstable but when doped with other foreign elements it becomes more stable. Se-Ge system is more interesting material for metallic switching, infrared optics, optoelectronic devices and memory elements. Addition of third dopants makes these glasses more stable and extend glass formation region.

New fabrication processes are under continuous development in the commercial and research fields. In today's market, there exists an increasing requirement for low cost, highly reliable functional humidity sensors. In this thesis Se-based chalcogenide thin films are used as sensing element for humidity sensors. It was observed that the doping of As/Sb in the parent Ge-Se-Te matrix enhances the sensitivity of the material. Doping also effects on response and recovery time of the prepared chalcogenide thin films. The formed sensing element were recorded as stable for several months in the same condition. Optical and thermal investigations of the prepared samples are also discussed in this thesis.

Present thesis consist of five chapters. The general information about humidity sensors is discussed in Chapter 1. **Chapter 1** consists of definition of humidity, different types of humidity sensors, sensor parameter and previously studied sensors for humidity sensing. This chapter also contains the principle of operation of resistive humidity sensors. The selection of problem for present thesis is also presented in this chapter. The introduction to chalcogenides, history of chalcogenides, material preparation, structural and optical properties are discussed in this chapter.

Chapter 2 describes various techniques involved in the preparation and characterization of the studied samples. The materials have been prepared using melt-quench technique and thin films have been prepared with vacuum thermal evaporation unit. Rigaku mini flex 600 Desktop X-Ray Diffraction system have been used for XRD measurement of samples while for DSC Differential Scanning Calorimeter (Metler Toledo) has been used. SEM has been carried out by Zeiss EVO40 scanning electron microscope and the infrared spectroscopy has been obtained using Nicolet iS5 Fourier Infrared spectrophotometer in the range of 4000-400 cm^{-1} with resolution 2 cm^{-1}. The transmittance spectra of prepared samples are obtained using UV-Vis double beam spectrophotometer (Model No: UV5704SS ECIL Hyderabad).

Chapter 3 describes the optical properties of prepared chalcogenides glasses and their thin films obtained with thermal evaporation method. The structural, thermal and optical properties of prepared samples are also discussed in this chapter. The synthesized materials have been characterized by XRD and SEM to confirm the amorphous nature of samples. The DSC technique has been carried out to find the composition dependence of samples on thermal characteristics. The infrared spectroscopy has also been introduced in this chapter and transmittance spectra has been used for calculating different optical parameters.

Chapter 4 describes the humidity sensing characteristics of prepared samples. The impedance based humidity sensor setup is described in the chapter including hygrometer and impedance analyzer. The different sensing parameters required for sensing characteristics have been described in this chapter. The effect of doping of foreign elements in parent matrix is also discussed in the chapter.

Chapter 5 is the overall conclusion of the entire work presented in the thesis. Current research work and future scope of Se based chalcogenide sensing membrane has also been discussed in this chapter.